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MOVABLE-WALL COKE OVEN TESTS AND RELATED ANALYSES OF COAL SAMPLES FROM SEAM 8, UPPER, LOWER AND RIDER, FROM HORSESHOE RIDGE SUBMITTED BY CROWS NEST RESOURCES LIMITED

Project No. 03-3-1/11-6
Job No. 3290R

J.G. JORGENSEN, T.A. LLOYD and W. GARDINER
COAL RESOURCE AND PROCESSING LABORATORY

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by

J.G. Jorgensen*, T.A. Lloyd* and W. Gardiner*

INTRODUCTION

This investigation deals with the carbonization and related analyses of cleaned coal samples from Seam 8 Upper (Adit No. 13), Seam 8 Lower (Adit No. 14) and Seam 8 Rider (Adit 14) taken from Horseshoe Ridge in the Upper Elk Coal Field. In addition to carbonizing the coals individually, two blends were tested, one composed of four parts Seam 8 Lower with three parts Seam 8 Rider and the other composed of four parts Seam 8 Upper and one part Seam 8 Rider. The project was initiated by R. Crisafio, Senior Metallurgist, Crows Nest Resources Limited, Calgary, Alberta in a letter dated June 5, 1980 which appears in Appendix 1.

The cleaned bulk coal samples were carbonized in the 12-inch width movable-wall coke oven located at the CANMET Bells Corners Complex near Ottawa. Representative samples of the coals were taken and analyzed for chemical, physical, thermal rheological and petrographical properties. The results of the testing and analyses are listed in Tables 1 to 6.

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*Heads, Coal Petrology Section, Coal Treatment and Rheology Section, and Carbonization Operations Section, respectively, Coal Resource and Processing Laboratory, Energy Research Laboratories, CANMET, Department of Energy, Mines and Resources, Ottawa, Canada.

TABLE 1 Chemical Analyses of Component Coals

Identification					
Laboratory Number	4086-80	4087-80	4209-80	4218-80	4218-80
Description	Blend 4 parts - Seam 8L 3 parts - Seam 8 Rider	Blend 4 parts - Seam 8U 1 part - Seam 8 Rider	Adit 14 Seam 8 Rider	Adit 14 Seam 8 Lower	Adit 13 Seam 8 Upper
Classification					
Rank (ASTM)	mvb	mvb	mvb	mvb	mvb
International System	431	431	433	421	421
Specific Volatile Index	195	194	195	182	185
Carbon (dmmfb) .....%	89.4	89.8	90.3	90.1	90.4
Proximate Analysis (db)					
Ash .....%	9.7	9.3	9.9	9.2	8.8
Volatile Matter .....%	21.5	21.4	21.5	22.0	21.9
Fixed Carbon .....%	68.8	69.3	68.6	68.8	69.3
Gross Calorific Value (db)					
Btu per pound	13970	14010	13930	13810	13930
Ultimate Analysis (db)					
Carbon .....%	79.9	80.6	80.4	80.9	81.6
Hydrogen .....%	4.9	4.9	4.4	4.4	4.4
Sulphur .....%	0.55	0.44	0.69	0.47	0.35
Nitrogen .....%	0.8	0.9	1.0	1.1	1.0
Ash .....%	9.7	9.3	9.9	9.2	8.8
Oxygen (by difference) .....%	4.1	3.9	3.6	3.9	3.8
Ash Analysis (db)					
SiO_2 .....%	55.5	53.4	60.2	54.0	51.2
Al_2O_3 .....%	30.6	32.4	29.9	30.7	32.3
Fe_2O_3 .....%	5.9	5.6	3.1	7.7	6.3
TiO_2 .....%	2.0	1.8	1.7	2.3	1.8
P_2O_5 .....%	0.7	1.8	0.2	1.1	2.2
CaO .....%	1.0	1.9	0.5	1.3	2.4
MgO .....%	0.5	0.5	0.4	0.6	0.4
SO_3 .....%	0.8	1.0	0.5	0.8	0.9
Na_2O .....%	0.0	0.0	0.1	0.1	0.1
K_2O .....%	0.7	0.5	0.9	0.5	0.5

TABLE 2 Physical Tests and Fusibility of Ash of Component Coals

Identification						
Laboratory Number		4086-80	4087-80	4209-80	4218-80	4219-80
Description		Blend 4 parts - Seam 8L 3 parts - Seam 8 Rider	Blend 4 parts - Seam 8U 1 part - Seam 8 Rider	Adit 14 Seam 8 Rider	Adit 14 Seam 8 Lower	Adit 13 Seam 8 Upper
Coal Pulverization						
Sieve Analysis						
Passing	Retained On					
	1/4 in.	%	0.2	0.2	0.3	0.3	0.2
1/4 in.	6 mesh	%	14.2	11.7	16.5	16.5	13.4
6 mesh	12 mesh	%	18.4	18.4	19.2	19.3	18.9
12 mesh	20 mesh	%	19.7	20.0	20.1	20.1	20.6
20 mesh	.....	%	47.5	49.7	43.9	43.8	46.9
Total Passing	6 mesh	%	85.6	88.1	83.2	83.2	86.4
Grindability							
Hardgrove Index			79	79	83	78	79
Fusibility of Ash							
Initial Deformation Temp. ...		°F	2700+	2700+	2700+	2650	2650
Softening Temp. Spherical ...		°F	2700+	2700+	2700+	2700	2700+
Softening Temp. Hemispherical		°F	2700+	2700+	2700+	2700+	2700+
Fluid Temp.		°F	2700+	2700+	2700+	2700+	2700+

TABLE 3 Thermal Rheological Properties of Component Coals

Identification					
Laboratory Number	4086-80	4087-80	4209-80	4218-80	4219-80
Description	Blend 4 parts - Seam 8L 3 parts - Seam 8 Rider	Blend 4 parts - Seam 8U 1 part - Seam 8 Rider	Adit 14 Seam 8 Rider	Adit 14 Seam 8 Lower	Adit 13 Seam 8 Upper
Linear Expansion					
Bd. 52 lb/ft^3 at 2% moisture...%					
Gieseler Plasticity					
Start .....°C	446	454	442	452	454
Fusion Temp. .....°C	-	-	456	-	-
Max. Fluid Temp. .....°C	469	471	473	469	463
Final Fluid Temp. .....°C	487	479	493	484	477
Solidification Temp. .....°C	490	488	497	487	485
Melting Range .....°C	41	25	55	32	23
Max. Fluidity .....dd/m	4.8	1.8	43.5	2.5	1.5
Torque .....g.in.	40	40	40	40	40
Dilatation					
Ti - Softening Temp. .....°C	411	421	408	413	422
Tii - Max. Contraction Temp. °C	464	482	453	500	500
Tiii - Max. Dilatation Temp. .°C	-	-	482	-	-
Contraction .....%	24	22	29	27	22
Dilatation .....%	Nil @ 500	Nil @ 500	7	Nil @ 500	Nil @ 500
Free Swelling Index					
F.S.I.	6½	4	7½	3½	2½

TABLE 4 Petrographic Analysis of Component Coals

Identification					
Laboratory Number.....	4086-80	4087-80	4209-80	4218-80	4219-80
Description.....	Blend 4 parts - Seam 8L 3 parts - Seam 8 Rider	Blend 4 Parts - Seam 8U 1 Part - Seam 8 Rider	Adit 14 Seam 8 Rider	Adit 14 Seam 8 Lower	Adit 13 Seam 8 Upper
Distribution of Vitrinite Types					
V-6.....%					
V-7.....%					
V-8.....%					
V-9.....%					
V-10.....%	1.1				
V-11.....%	1.7	1.6	1.3	2.3	3.9
V-12.....%	27.1	20.6	20.6	18.0	21.3
V-13.....%	25.9	30.2	39.3	23.5	20.3
V-14.....%	0.6	0.5	3.3	2.3	2.8
V-15.....%					
V-16.....%					
V-17.....%					
V-18.....%					
Reactive Components					
Total Vitrinite.....%	56.4	52.9	64.5	46.1	48.3
Reactive Semi-fusinite (1/2)...%	13.4	13.8	10.8	17.6	15.7
Exinite.....%	0.0	0.2	0.1	0.0	0.0
Total.....%	69.8	66.9	75.4	63.7	64.0
Inert Components					
Inert Semi-fusinite (1/2).....%	13.4	13.9	10.9	17.6	15.7
Micrinite.....%	2.7	3.0	3.0	4.5	5.2
Fusinite.....%	8.6	11.0	5.1	9.0	10.2
Mineral Matter.....%	5.5	5.2	5.6	5.2	4.9
Total.....%	30.2	33.1	24.6	36.3	36.0
Petrographic Indices					
Mean Reflectance.....%	1.29	1.30	1.32	1.30	1.30
Balance Index.....	1.96	2.34	1.60	2.69	2.57
Strength Index.....	5.22	5.31	5.40	5.22	5.15
Stability Index.....	55.5	52.7	60.5	49.6	50.0

TABLE 5 - Carbonization Data

Test Identification Number	803		804		807		808		809	
Data of Test	Sept 9/80		Sept 11/80		Sept 23/80		Sept 24/80		Sept 29/80	
Laboratory Number										
Description	4 parts Seam 8 Lower 3 parts - Rider		4 parts Seam 8 upper 1 part - Rider		Adit 14 Seam 8 Rider 100%		Adit 14 Seam 8 Lower 100%		Adit 13 Seam 8 Upper 100%	
CARBONIZATION DATA										
Net Weight of Charge (wet) lb	532.4		560.1		562.5		575.7		560.1	
Moisture in Charge %	3.2		2.6		2.8		2.6		3.0	
ASTM Bulk Density (wet) lb/ft^3	48.5		48.5		48.5		48.5		48.5	
Oven Bulk Density (db) lb/ft^3	47.55		50.32		50.43		51.72		50.12	
CARBONIZATION RESULTS										
Gross Coking Time hr:min	8:50		9:00		9:15		9:05		9:05	
Maximum Wall Pressure lb/in^2	0.44		0.75		3.95		0.64		0.52	
Coke Yield Actual %	79.3		78.4		80.1		82.4		77.8	
Mean Coke size in	2.02		1.98		2.03		1.99		1.91	
Apparent Specific Gravity	0.967		1.004		0.952		0.996		1.016	
Screen Analysis of Coke (cumulative percentage retained on)										
3 inch sieve	8.9		10.4		8.6		11.0		8.9	
2 inch sieve	46.8		43.5		47.0		43.7		41.5	
1 1/2 inch sieve	73.9		72.3		76.0		71.2		69.6	
1 inch sieve	93.7		92.4		94.2		92.4		88.9	
3/4 inch sieve	95.4		94.4		96.1		94.6		90.7	
1/2 inch sieve	96.4		95.3		97.0		95.3		91.6	
Percentage -1/2 inch (breeze)	3.6		4.7		3.0		4.7		8.4	
Tumbler Test (ASTM)										
Stability Factor	51.9		50.4		58.0		52.2		44.5	
Hardness Factor	66.4		65.9		69.1		68.9		60.1	
Japanese Drum Test (JIS) (cumulative percentage retained on)	*	**	*	**	*	**	*	**	*	**
50 mm sieve	14.7	4.8	3.0	1.1	16.6	2.3	9.4	0.8	9.6	-
25 mm sieve	85.7	66.9	82.5	61.6	89.8	73.4	82.9	64.0	78.1	56.4
15 mm sieve	93.0	81.6	91.1	78.7	93.7	83.5	92.5	80.3	86.5	70.5

*30 revs **150 revs

TABLE 6

Analyses of Coke Oven Charges and Resultant Cokes

Identification					
Test Number.....	803	804	807	808	809
Date Charged.....	9/9/80	10/9/80	23/9/80	24/9/80	30/9/80
Description.....	Blend 4 parts - Seam 8L 3 parts - Seam 8 Rider	Blend 4 parts-Seam 8U 1 part -Seam 8 Rider	100% Adit 14 Seam 8 Rider	100% Adit 14 Seam 8 Lower	100% Adit 13 Seam 8 Upper
Coke Oven Charge					
Laboratory Number.....	4086-80	4087-80	4209-80	4218-80	4219-80
Proximate Analysis (db)					
Ash.....%	9.7	9.3	9.9	9.2	8.8
Volatile Matter.....%	21.5	21.4	21.5	22.0	21.9
Fixed Carbon .....%	68.8	69.3	68.6	68.8	69.3
Sulphur (db).....%	0.55	0.44	0.69	0.47	0.35
Resultant Coke					
Laboratory Number.....	4205-80	4206-80	4341-80	4342-80	4343-80
Proximate Analysis (db)					
Ash.....%	11.6	11.3	12.6	11.8	11.6
Volatile Matter.....%	1.3	2.1	1.8	2.0	2.1
Fixed Carbon.....%	87.1	86.6	85.6	86.2	86.3
Sulphur (db).....%	0.49	0.31	0.51	0.39	0.34

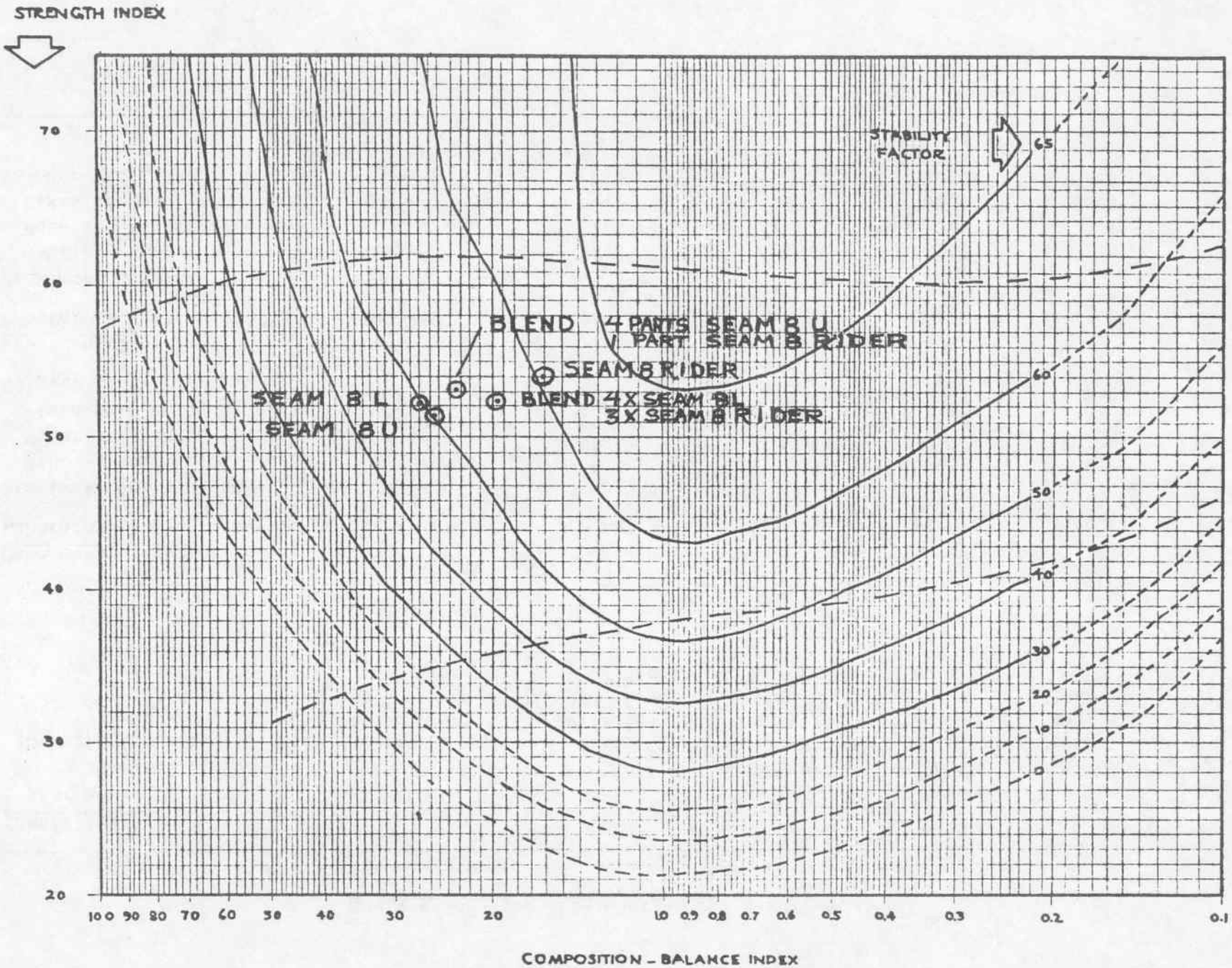
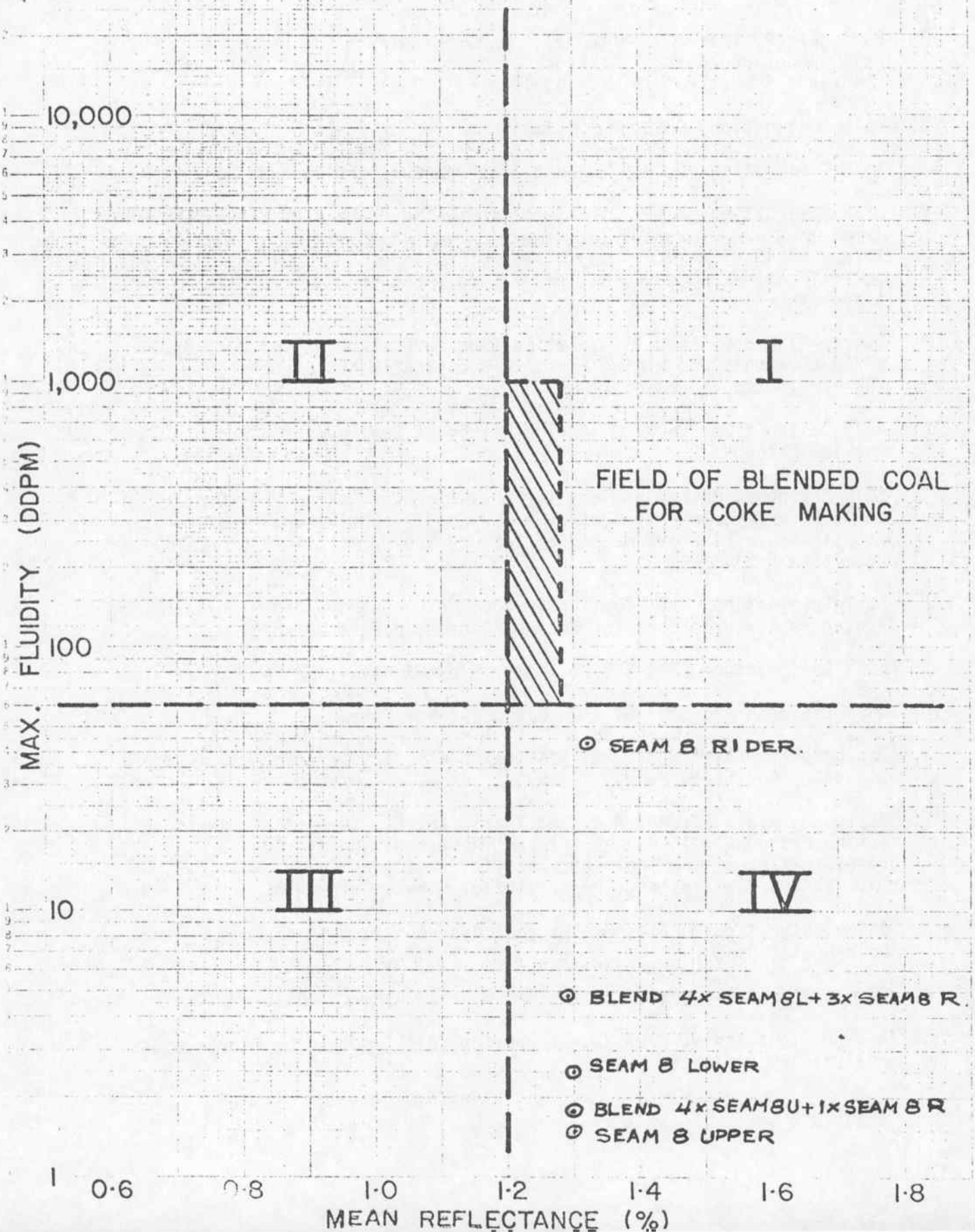


Figure 1. Plot of Predicted Stability Index of Component Coals from Petrographic Data.

Figure 2. RELATIONSHIP BETWEEN MAX. FLUIDITY AND MEAN REFLECTANCE.



BIBLIOGRAPHY

1. Eddinger, R. Tracy and Mitchell, John, "Pilot-Scale Coke Ovens - Development and Operation; Proc. of Blast Furnace, Coke Oven and Raw Materials Committee", AIME, 15, 148-163 (1956).

2. ASTM Designation: D388-66, "Classification of Coals by Rank".

3. ASTM Designation: D720-67, "Test for Free Swelling Index of Coal".

4. ASTM Designation: D2639-71, "Test of Plastic Properties of Coal by the Constant-Torque Gieseler Plastometer." (Constant torque plastometer used with a torque of 40 gram-inch; start, 1 dd/m; fusion, 5 dd/m; final, 1 dd/m; solidification, no movement; range-temp., between start and final temperatures).

5. Burrough, E.J., "Specific Volatile Index", Fuels Division Memorandum 97/58-CG, Fuels and Mining Practice Division, Mines Branch, Dept. of M. and T.S., Ottawa, Canada (1958).

6. ASTM Designation: D409-71, "Grindability of Coal by the Hardgrove-Machine Method".

7. ASTM "Proposed Method of Test for Measuring the Coking Pressures of Coals by a Movable-Wall Slot Oven" (presently under consideration for adoption as a standard method of test by Sub-Committee XV of ASTM Committee D-5).

8. ASTM Designation: D291-60, "Cubic Foot Weight of Crushed Bituminous Coal" Procedure A - Procedure for Uncompacted Cubic Foot Weight).

9. ASTM Designation: D293-69, "Test for Sieve Analysis of Coke".

10. ASTM Designation: D294-64, "Tumbler Test for Coke".

11. Japanese Drum Test for Coke, Designated as J.I.S. (Japanese Industrial Standard) K 2151-1972, pp. 12-16).

12. Burrough, E.J., Strong, R.A. and Swartzman, E., "Report of Investigation on the Method Now in Use at the Fuel Research Laboratories for Determination of the Apparent Specific Gravity of Coke", R.I. C.S. 35, Division of Fuel Testing, Department of Mines, Ottawa, August 24, 1934.

13. ASTM Designation: D2014-71, "Expansion or Contraction of Coal by the Sole-Heated Oven".

14. German Industrial Specification No. DIN 51739/March 1951.

15. ASTM Designation: D-2797-72, "Preparing Coal Samples for Microscopical Analysis by Reflected Light".

16. ASTM Designation: D-2798-72, "Microscopical Determination of the Reflectance of the Organic Components in a Polished Specimen of Coal".

17. ASTM Designation: D-2799-72, "Microscopical Determination of Volume Percent of Physical Components of Coal".

18. Schapiro, N., Gray, R.J., "Petrographic Classification Applicable to Coals of all Ranks", Proc. 111, Min. Inst., 1960, 68, 83-97.

19. H. Hoffmann, and K. Hoehne, Brenstoff Chemie, 35, (1954), pp 202, 236, 269 and 298.

APPENDIX 1

Letter dated June 5, 1980 from R. Crisafio, Senior Metallurgist, Crows Nest Resources Limited, Calgary, Alberta.

Crows Nest Resources LIMITED
Suncor Tower, 500 - 4th Avenue S.W., Calgary, Alberta (403) 232-4355
P.O. Box 2699 Stn. M, Calgary, Alberta T2P 2M7 Telex 038-24792

June 5, 1980

Dr. T.D. Brown, PhD., C.Eng.,
Energy Research Laboratory,
Energy Mines and Resources,
555 Booth Street,
Ottawa, Ontario.
K1A 0G1.

Dear Dave:

Following a discussion with J. Jorgenson, C.N.R.L. will be submitting for carbonization tests coals from the Horseshoe Ridge area near the Line Creek properties.

We will be forwarding shortly three seams for individual carbonization and related quality testing, to be followed later by a fourth seam and possibly some blend tests.

I am not stating number of tests in the Purchase Order for Horseshoe Ridge since this is simply an estimate at this time for budgeting purposes.

Thanks to your Department for their considerable assistance in these matters.

Yours very truly,

R. Crisafio,
Senior Metallurgist.

RC/ljr